Funding forms, market conditions and dynamic effects of government R&D subsidies: evidence from China[*]

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Abstract

We examine various factors that influence the effects of government-subsidized research and development (R&D) programs on firm productivity. Based on a panel dataset of Chinese firms, we find the effects of the Innovation Fund for Small and Medium Technology Based Firm (Innofund) are dynamic over time and are heterogeneous depending on funding forms and the level of marketization and economic development across regions. In general, Innfound has significant and positive effects on firm productivity in both short and long run. However, the short-term effects of Innofund are stronger than the long-term ones. Additionally, the positive effects of Innofund are stronger for firms backed by interest-free bank loans than those supported by appropriation. Meanwhile, Innofund has stronger positive effects in provinces that are less market-oriented or less developed economically. Finally, the short-term effects of Innofund are stay stronger than the long-term ones even after we control the funding forms and the market conditions across-regions. Identification and selection concerns are addressed through the propensity score matching approach and two-stage estimation.

Key words: government R&D program, firm productivity, dynamics, marketization, funding forms

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[*] We are grateful for the helpful comments from three anonymous referees. Special thanks go to Professor Keith Maskus for his guidance and insightful comments on different versions of this paper. Comments from Adam Jaffe, Saul Lach, Larry Qiu, Zhigang Tao, Chenggang Xu, Bo Zhao and seminar participants at the University of Hong Kong, Hebrew University and Peking University are appreciated. We thank Jing Qian for her excellent research assistance. All errors remain ours. Di Guo and Kun Jiang acknowledge financial support from RGC Theme-based Research Scheme (TRS) (T31-717 112-R). Yan Guo acknowledges financial support from Peking University.

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I. Introduction

Government funding for corporate research and development (R&D) activities is introduced as a solution for the market failure of underinvestment in R&D by profit-driven enterprises (Nelson, 1959; Arrow, 1962; Hall and Lerner, 2010). However, empirical evidence regarding the effects of government-subsidized R&D remains inconclusive. Some studies find that government-subsidized firms achieve higher productivity and profitability compared to firms not supported by government subsidies (Griliches and Regev, 1998; Branstetter and Sakakibara, 1998). Moreover, such firms grow faster (Lerner, 2000), more successfully access other external finances (Lerner, 2000; Aschhoff, 2010), invest more in R&D activities (Audretsch et al., 2002; Lach, 2002; Görg and Strobl, 2007; Aerts and Schmidt, 2008; Czarnitzki and Lopes-Bento, 2013), and generate higher social returns than their counterparts do (Griliches and Regev, 1998; Irwin and Klenow, 1996). Nevertheless, a considerable number of studies indicate that public R&D programs do not stimulate firm performance (Klette and Møen, 1998) or exert limited positive effects on corporate R&D spending except for small firms (Lööf and Hesmati, 2005) or research-oriented projects (Clausen, 2009). Moreover, several studies determine that government R&D subsidies actually crowd out private R&D inputs, consequently reducing social welfare and growth (Wallsten, 2000; Busom, 2000; Acemoglu et al., 2013).

The mixed findings indicate that the effects of government R&D programs may not be straightforward; rather, such effects may differ across markets, depend on the funding forms, and be dynamic after the infusion of subsidies (Klette et al., 2000; David et al., 2000). Nonetheless, most existing works regard government R&D programs as a whole to either examine the general effects of such programs or to capture one of the aforementioned factors. To our knowledge, no research has been conducted to examine how the different factors influence the effects of government subsidy programs simultaneously.

Our present study attempts to fill this knowledge gap by examining the different factors that may influence the effects of Innovation Fund for Small and Medium Technology-based Firms (Innofund). Innofund is one of the largest programs developed by the Chinese government that aim to support the corporate R&D activities of small and medium-sized enterprises (SMEs). First, we examine the general effects of Innofund on firm productivity. Second, we compare the short-term and long-term effects of such program to determine whether or not Innofund effects are dynamic over time after the infusion of subsidies. Third, we examine whether the different funding forms of government subsidies exert varying effects on firm productivity. Forth, we investigate whether the effects of the government initiatives vary under different market conditions.

This current research is relevant for the following reasons: first, the Chinese government has been deeply involved in business and resource allocation (Li et al., 2008; Guo et al., 2014; Guo et al., 2015). Existing studies mainly emphasize the effects of government R&D initiatives on economies with free markets to determine how government subsidies adjust market failures. Nonetheless, how such government R&D programs work in an economy in which the government is deeply engaged in business activities, such as in the case of China, is lack of scrutiny. Second, the institutional background in China and the operation of Innofund provide a good opportunity to examine the effects of such program from different aspects. Innofund is a nationwide R&D program in China that has been operating for 16 years and offers different forms of funding across various regions. This program therefore facilitates investigation into how different funding forms affect firms across various regions in both long-term and short-term aspects. The present investigation into the varying factors influencing the effects of government funding through the same program within the same country over time may help us rule out the potential identification concerns in cross-country or cross-program studies. Hence, this study assists in identifying the circumstances under which government funding significantly affects firms. Third, innovation and progress in science and technology comprise the top agenda of the Chinese government. Public support for industrial innovation in China attracts global interest because such an initiative profoundly influences the sustainability of China's growth and the competitive landscape of the global economy; nonetheless, systematic examinations of the consequences of government R&D programs in China remain limited.

Based on a panel dataset of Chinese manufacturing firms between 1998 and 2007, we find that firms backed by Innofund exhibit significantly magnified increases in productivity following the infusion of funds. Moreover, we observe a stronger effect of Innofund in short run than that in long run. Additionally, the effects of Innofund vary according to the forms of support. Firms that are supported by interest-free bank loans enjoy significantly higher increases in productivity than those supported by appropriation. Finally, the effects of Innofund vary across regions; these influences are stronger in regions less market-oriented or less developed economically than in other regions.

We use two approaches to address the identification issues, i.e. the potential selection biases and effects of unobservable factors. We first use propensity score matching (PSM) to match Innofund-backed with non-Innofund-backed firms in relevant dimensions to build up a control group. Such procedure is a quasi-experiment approach employed to reduce selection issues effectively. We then perform two-stage estimations with two instrumental variables (IVs) to deal with concerns with omitted variables and identify the ex-post effects of Innofund. The first IV is the total number of firms in the high-tech zones of the city in which the firm is located in each given year. The second IV is the ratio of total investment in fixed assets made by local governments over total GDP in the county in which the firm is located in each given year. The two-stage estimations confirm the causality of the significantly increased productivity of Innofund-backed firms and the government subsidies.

The remainder of this paper is organized as follows: Section 2 introduces the institutional background of the Innofund program. Section 3 discusses how the hypotheses are developed. Section 4 describes the sample and the data. Section 5 presents the findings on the general and dynamic effects of Innofund and addresses the potential identification concerns. Section 6 discusses the effects of this program with different forms of support and under various market conditions. Section 7 concludes this study.

II. Introduction on the Innofund program

Innofund is a government R&D program that was established with the approval of the State Council in May 1999 with the aim to "*facilitate and encourage the innovation activities of small and medium technology-based enterprises (SMTEs)*"[1]. It is currently the largest government program supporting corporate R&D activities of SMTEs in China.

The principal criteria for Innofund application are focused on three aspects. First, the project should comply with national industrial technology policies and have high potential economic and social benefits. Second, the annual R&D investment of the firm

[1]Source: http://www.innofund.gov.cn/

should be at least more than 3% of its total sales, and the number of direct R&D employees should be more than 10% of the total number of employees. Third, a qualified applicant should be a SMTE with no more than 500 employees.

Innofund mainly provides three forms of financing, namely, appropriation, interest-free bank loans, and equity investment. Appropriation is the major start-up capital provided to small firms that have been founded by research personnel with their own scientific achievements. Interest-free bank loans are mainly provided to SMTEs which plan to expand the production scale of innovation projects. Equity investment is generally reserved for projects with high levels of technology, high innovation capacity, and market potential in the emerging industries. The total amount of subsidy for an individual project generally ranges between 1 and 2 million RMB. Innofund has provided more than 19.17 billion RMB of funding to 30,537 projects in the period of 1999 to 2011. Among the 30,537 projects backed by Innofund between 1999 and 2011, 27,498 (more than 86% of the total) are backed by appropriation, 2,880 by interest-free bank loans, and 1,159 by other funding forms, including bank loan warranty and equity investment.

By average, Innofund granting duration is three years. Innofund Administration Committee (IAC) is in charge of monitoring and evaluating the performance of the awarded projects after the infusion of the subsidies. Upon the completion of the contracts, IAC would organize a panel of experts to evaluate whether the projects have achieved the desired targets. If a firm fails the final evaluation, it will not be qualified to apply for Innofund (or even other government R&D programs) for a period of time.

III Funding forms, market conditions and dynamic Innofund effects

3.1 Dynamic effects of government R&D subsidies

The effects of public R&D programs on firm productivity may vary in the short and long runs. First, the dynamic effects of government subsidies for corporate R&D may depend on the tradeoffs between the adjustment costs of R&D investment and the liquidity constraints faced by firms. Investing in R&D activities is a complicated decision-making and implementation process that involves handling new resources or reallocating existing firm resources (Lucas, 1967). If an awarded firm would otherwise choose to finance itself regardless of whether it gains public R&D subsidies or not, we expect that the adjustment costs of additional R&D investment may become too high for the company in the short run. In this situation, government support may serve as a substitute to the private R&D investment that exerts limited effects on R&D investments and firm productivity in the short term. However, if the awarded firm should choose not to finance itself, we expect the firm to move quickly with government support and observe the effects of the public R&D program within a short period of time. When the adjustment costs of R&D investment are considered, we infer that the stronger the liquidity constraints faced by firms are, the stronger the observed effects of government subsidies are in the short run. Empirically, Lach (2002) and Lööf and Hesmati (2005) find that government subsidies are particularly strong in the short run (normally within one to three years after the infusion of subsidies) for small firms which are usually expected to face high-level liquidity constraints.

Second, the dynamic effects of public R&D programs may also be related to the existence of the certification effects of such programs (Lerner, 2000; Meuleman and De Maeseneire, 2008). Projects backed by government subsidies have precise duration and are assessed by administrative agencies once the granting period expires. Failing this assessment may send negative signals to potential external financiers; hence, firms may have to prove their performance within the duration of the government granting period in addition to the concerns related to the adjustment costs. Therefore, we should expect the short-run effects of such government R&D programs to be strong, especially when external finance is important for firms. Indeed, public R&D programs exert significant positive short-term influences (within one to three years after the infusion of public R&D subsidies), as per empirical analysis (e.g., Levy and Terleckyj, 1983; Mansfield and Switzer, 1984; Lichtenberg, 1984; Guellec and Van Pottelsberghe, 2000; Callejón and García-Quevedo, 2005).

Third, public R&D programs may also exert long-run effects given that R&D activities are performed as a learning-by-doing process. Firms accumulate knowledge capital over time via this process in R&D activities. Therefore, the infusion of public R&D subsidies may have long-term effects on firm performance as a result of the increased knowledge capital. Indeed, Klette and Møen (2012) and Bentzen and Smith (1999) reveal the positive and significant long-term influence of public R&D programs on private R&D in Norway and Denmark, respectively.

In the case of the Innofund program in China, we expect to observe significant and positive effects in both the short and long runs. However, we expect the short-term effects to be stronger than those in the long term. First, SMTEs in the private sector, which are the major target of Innofund support, face severe financial constraints due to the lack of access to external financial resources.[2] Such situation suggests that government R&D subsidies may be important complementary resources for SMTEs to investment in R&D activities. Second, information issues in R&D investment are significant. In addition, the credit record system is far from well-established in China. The certification effects of government R&D programs, which may lead to additional sources of external finance for SMTEs, are therefore important. As discussed earlier, the typical Innofund granting period is three years. Thus, we expect firms to react to the R&D subsidies quickly and to perform within the first three years after they are awarded. Third, it is well documented that the R&D expenditure in China is disproportionally focused on development rather than research.[3] We therefore expect that the learning curve for R&D investment in China is shorter that implies more obvious effects of government R&D subsidies in short run comparing to those in developed economies.

3.2 Funding forms and the effects of government R&D subsidies

Government R&D programs support private R&D activities through two major instruments, namely, tax incentives and direct subsidies. Existing literature mainly focuses on effects of tax incentives and finds tax credits have positive effects on R&D activities (Hall and Van Reenen, 2000; Bloom et al. 2002). Nonetheless, to our knowledge, no study has tested the effects of the different forms of direct R&D subsidies.

R&D subsidies in different forms may provide varied incentives to awarded firms through different mechanisms and thereby influence the effects of such subsidies. By nature, R&D investment is associated with profound information issues and a high level of uncertainty. Consequently, agency problems with R&D investment can be severe and the incentives offered by the government subsidies of different funding forms are essential to influence the effects of such subsidies. For instance, appropriation mainly

[2] According to Guo et al. (2014), the ratio of bank loan over equity for private enterprises were 0.6% and 0.8% in 2006 and 2008, respectively. Moreover, Chinese firms generally have considerably higher proportions of short-term debt related to their capital structures than firms in other countries do (Li et al., 2009).

[3] See OECD Science, Technology and Industry Scoreboard (2015).

relies on an ex-ante screening mechanism that does not impose hard constraints on a firm after funding infusion. Given the adjustment costs and uncertainty of R&D activities, risk-averse executives or lazy managers may be reluctant to respond to R&D subsidies in appropriation on time (Holmström, 1982; Hart, 1983; Qian and Xu, 1998; Bertrand and Mullainathan, 2003). As a comparison, interest-free bank loans and equity investment rely on both ex-ante and ex-post screening mechanisms. Although awarded firms may enjoy preferred or free interest for the bank loans, companies face increased leverage ratio and the pressure of defaulting if they are awarded with bank loans. The threat of bankruptcy or takeover may harden the budget constraints of firms and thereby force managers to work hard at innovating, particularly when the market competition is high (Dewatripont and Maskin, 1995; Aghion et al., 2013). We therefore expect to observe significantly stronger magnified increases in firm productivity for firms that win interest-free bank loans than for firms that gain appropriation upon obtaining Innofund support.

3.3 Market conditions and the effects of government R&D subsidies

The level of marketization and economic development of a region may affect the level of financial constraints and the marginal rate of return from private R&D activities of firms; as a result, the incentives of firms to invest in R&D activities and the influences of government R&D programs are affected.

In a market-oriented or economically developed region, firms are expected to have much access to different external financial resources and to face intensive competition. The increased access to external finance may relax financial constraints of firms for investment in R&D activities in market-oriented or economically developed regions. Meanwhile, competition may increase the incremental profits of firms from innovation; therefore, companies are encouraged to invest heavily in R&D activities even without government R&D incentives to escape competition (Aghion et al., 2005). With improved access to external finance and a high marginal private rate of return from innovation, firms in market-oriented or economically developed regions may have strong incentives to invest in R&D activities through their own internal financing recourses or by seeking other financial resources even with limited government support. Indeed, empirical studies discover that the effects of public R&D subsidies across countries exhibit significant heterogeneity (Guellec and Van Pottelsberghe, 2000; Cincera et al., 2009). Moreover, a few works based on US data demonstrate a crowding-out effect of public R&D programs (e.g., Wallsten, 2000; Acemoglu et al., 2013), while most studies based on data from non-US countries find the universally positive effects of such programs despite the variation in the degree of complementary influence (e.g., Lach, 2002; Cincera et al., 2009; Czarnitzki and Lopes-Bento, 2013). The mixed findings may reflect the influences of the marketization or economic development level on the effects of government R&D programs across-countries.

China is large and heterogeneous in both institutional aspects and economic endowments (Xu, 2011). Innofund has been operating for 16 years since 1999 in almost all provinces in this country. Based on the reasoning presented above, we predict that the Innofund effects will be weaker in provinces with a higher marketization level or a higher level of economic development than in other provinces.

IV. Data, samples, and total factor productivity (TFP) estimation

Our data are obtained from two major sources. First, basic information on Innofund-backed firms is derived from the Innofund program website (http://www.innofund.gov.cn). The website provides the name and address of an awarded firm, the nature of the project, the date of granting, the type of support, and the performance evaluation result of the project. Second, firm-level data on financial information and other firm-specific characteristics are derived from the "Above-scale Industrial Firms Panel 1998-2007" (ASIFP), which is composed of all state-owned manufacturing firms and non-stated-owned manufacturing firms with annual sales of at least 5 million RMB (US$750,000) in China between the years 1998 and 2007.[4]

We initially identify the Innofund-backed firms in ASIFP to obtain financial information and other data following the matching strategy by Guo et al. (2016).[5]

[4] ASIFP does not cover non-SOEs with annual sales below 5 million RMB; therefore, the sample may be biased and cause us to miss such micro-sized firms. We compare the data in ASIFP 2004 to those in the Chinese Economic Census 2004, which cover all firms in China. Enterprises covered by ASIFP account for more than 89% of the total sales of all industrial firms in China in 2004 (Based on the first Chinese Economic Census conducted in 2004, the total sales for all industrial firms was 218 billion RMB in 2003, whereas that for all ASIFP firms was 196 billion RMB in the same year), thereby suggesting that our sample should not introduce systematic biases into our analysis. According to Brandt et al. (2012), the coverage of ASIFP is identical to the corresponding information derived from the Chinese Statistical Yearbook.

[5] In principal, similar to the matching strategy used by Guo et al. (2016), we apply a three-stage matching strategy for the compuerized matching, which is similar to that used by the NBER Patent Data Project. We then further cross check the accuracy of the matching with manual matching.

Approximately 6,167 projects were backed by Innofund between 1999 and 2007 (including firms that received funding more than once). After matching, 2,638 firms that received at least one Innofund grant between 1999 and 2007 are identified from ASIFP dataset for estimation. The sample consists of 18,224 firm-year observations for Innofund-backed firms.[6]

We then construct a control group of non-Innofund-backed firms. We build the control group through several steps to ensure that our findings are not driven by a specific matching method. We initially derive firms that were eligible for Innofund but did not apply or did not win support in a given year from ASIFP based on the Innofund selection criteria, which are officially announced each year as introduced in Section2. After identifying the non-Innofund-backed firms, we randomly draw one-to-five matched pairs to build the control group of non-Innofund-backed firms while controlling for location (provincial level). Finally, 64,474 firm-year observations are obtained for 12,025 eligible firms that are unsupported by the Innofund program.

Productivity is measured on the basis of total factor productivity (TFP); we calculate this variable with two different approaches to achieve accuracy and to ensure that conclusions are not driven by a specific TFP measure.[7] The first measure (***TFP_ols***) is a straightforward OLS residual from a log-linear transformation of the general Cobb–Douglas production function. However, OLS production function estimates may be biased once the unobservable shocks correlate with input levels. The OLS method also lacks dynamic consideration. Hence, we follow Olley and Pakes (1996) by employing investment as a proxy for the unobservable productivity shocks in the second method.[8] We use this semi-parametric method to control for both the simultaneity caused by

[6] The detailed industry and year distribution of the sampled Innofund-backed firms are presented in Table B-1 of online appendix. Overall, 81% of the sampled Innofund-backed firms are in high-tech industries as defined by the NBS. The distribution of the awarding year for sampled firms and the full sample of Innofund-backed projects are indicated as well, suggesting the representativeness of our sample.

[7] A possible problem of using TFP to measure productivity is that if the innovative firm generates little revenue as a result of the introduction of a new product, TFP may become a biased measure for productivity. We therefore check the revenues and costs of firms. So far, we find that less than 5% of the firms in our sample report annual revenue of less than 1.8 million RMB. Furthermore, less than 3% of firms cannot break even on average (detailed summary is provided in Table B-2 of online appendix). Such summary statistics suggest that the aforementioned concern with potential biases in TFP calculation is not a major issue for this study.

[8] In principal, we follow the approach of Brandt et al. (2012) to define the major variables (e.g. production input, entry and exit, appreciation rate etc.) to calculate the TFP of firms.

unobserved productivity and the non-random sample selection induced by the different exit probabilities for small and large low-productivity firms. ***TFP_op1*** is the TFP calculated via the approach utilized by Olley and Pakes (1996) with time trends considered, whereas ***TFP_op2*** is the TFP of the firm without taking into account time trends. Detailed discussions on how we compute the TFPs are presented in online Appendix A.

We also control for several firm-specific variables, including age, size, leverage ratio, ownership structure, export and the presence of foreign investors. ***Firm_Age*** is measured by the logarithm form of the firm's age in a given year. ***Firm_Size*** is measured by the logarithm form of the total number of employees of the firm. ***Lvg_rt*** is the ratio of the total liability over the total assets of the firm in a given year. ***State_Shr*** is the ratio of state ownership over the total equity of a firm in a given year. Trade exposure and foreign investment may affect firm productivity; therefore, we add two control variables that indicate these two factors. ***Export_D*** is a dummy variable that equals to one if the firm generates exports in a given year and zero if otherwise. ***FDI_D*** is a dummy variable that equals to one if the firm has foreign shareholders in a given year and zero otherwise. The variables used are winsorized at the 1^{st} and 99^{th} percentiles to eliminate outliers.

Table 1 reports the summary statistics for relevant variables of Innofund-backed firms and of those in the control group for the entire time period of 1998 to 2007. On average, Innofund-backed firms have higher TFP than non-Innofund-backed ones do; moreover, the former firms are larger and have lower leverage ratios than the latter firms. The ages of the firms do not differ considerably. Furthermore, we consider the firms that are supported by Innofund either through interest-free bank loans or through direct appropriation separately. Firms supported by interest-free bank loans generate higher productivity than firms backed by appropriation do. Meanwhile, the former firms are larger and older on average than the latter firms.[9] Finally, firms backed by appropriation

[9] Table 1 shows that the maximum sizes (measured by the total number of employees) of both Innofund-backed and non-Innofund-backed firms are more than 500 that seem to contradict to the standard criteria of Innofund selection. The results are not driven by our matching/merging mistakes while identifying Innofund-backed firms or constructing the control group; rather, these outcomes are attributed to the following two reasons. First, a few Innofund-backed firms indeed exceeded the requirement of the program during the funding period, that is, the number of employees was larger than 500. To ensure estimation accuracy, we match these firms with non-Innofund-backed companies of similar size. Second and more importantly, the information presented in Table 1 indicates the firm-year observations across 10 years, whereas our matching of the control group is based on the size of the firms at the time of Innofund awarding. Some

have more state-shares and lower leverage ratios than firms supported by interest-free bank loans do.

V. Effects of Innofund and the dynamics of these influences

5.1 Basic findings

In this section, we discuss whether or not Innofund affects firm productivity in general and whether or not the effects change over time after the infusion of R&D subsidies. To address these questions, we construct four dummy variables to capture the difference before and after the infusion of Innofund and the time period of subsidy infusion. ***Inno_Aft*** is a dummy variable that equals to one if a firm has already received Innofund support in a given year and zero if otherwise. ***Bfr_Innofund*** equals to one for the period within six years before a firm received Innofund and zero if otherwise. ***Sht_Innofund*** equals to one for the period within three years after the firm received Innofund and zero if otherwise. ***Lg_Innofund*** equals to one for the period between four and eight years after the firm gained Innofund support and zero if otherwise.

Table 2 presents the results of the fixed-effect panel data regressions on the TFP of firms. In Models (1) to (3), we include only ***Inno_Aft*** to determine whether or not firm productivity improves considerably upon obtaining Innofund support. The result shows that ***InnoAft*** is significantly and positively associated with firm TFP, as measured with the two approaches discussed in the previous section. The results suggest that Innofund-backed firms generate significantly higher productivity than non-Innofund-backed firms and the firms themselves prior to fund infusion do. For example, Models (2) and (3) reveal that after winning Innofund grants, the TFP of Innofund-backed firms increased by 0.08 and 0.06 when measured by the OP method with and without time trends, respectively, in comparison with those of non-Innofund-backed firms and with the firms themselves before fund infusion. Moreover, the average TFP values measured by the OP method with and without time trends are 2.7 and 2.5, respectively, for Innofund-backed firms during the year the funding was won; this result indicates that the TFP of Innofund-backed firms with and without time trends increased by 2.96% and 2.40%, respectively, after fund infusion. Brandt et al. (2012) found that the average TFP growth rate is

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firms that received Innofund support previously grew into large firms over time; thus, such firms have significantly more than 500 employees on average.

approximately 8% for the aforementioned scale manufacturing firms between 1998 and 2007 in China. Thus, our study shows that Innofund contributes to roughly one-third of the growth of such rewarded firms.

Models (4) to (6) of Table 2 present the dynamics of Innofund influences by controlling for the ex-ante effects. The results show that ***Bfr_Innofund*** is significantly and positively associated with the firm TFP measured with the two approaches. The results suggest that Innofund-backed firms generate significantly higher productivity than non-Innofund-backed firms do before funds were infused; this outcome demonstrates the selection effects of Innofund. Meanwhile, both ***Sht_Innofund*** and ***Lg_Innofund*** are significantly and positively associated with firm TFP; this finding indicates both the short- and long-run positive effects of Innofund on firm productivity. However, the coefficients of ***Sht_Innofund*** are significantly larger than those of ***Lg_Innofund*** and ***Bfr_Innofund***, as indicated in the Lincom test results presented in Panel B. These outcomes show that the effects of Innofund on firm productivity within three years after fund infusion are stronger than the selection and the long-run influences of such a program. For instance, Model (5) suggests that the TFP of Innofund-backed firms is approximately 0.3 higher than those of non-Innofund-backed firms within three years of gaining subsidies when measured through the OP method with time trend. This finding indicates that in the short run, Innofund increases firm TFP by roughly 11%. By contrast, the gap between Innofund-backed and non-Innofund-backed firms in terms of TFP drops to 0.23 for the time period between four and eight years after obtaining Innofund support when measured via the same approach. Table 2 indicates that Innofund has significant and positive effects on firm productivity in both short and long run while the short-term effects are stronger than long-term effects. [10]

We also find that firm size, leverage ratio, and state ownership are significantly and negatively correlated with ***TFP***, which is consistent with the conclusion made by Hsieh and Klenow (2009). By contrast, firm age and trade exposure are significantly and

[10] To further investigate the dynamics of Innofund effects, we break down the time period further into an annual scale and rerun the estimations (we do not show the tables in this paper because of space limitation). The estimations show that the effects of Innofund increase for the first three years, that is, from the year of the funds were obtained, and that these influences peak in the third year after receiving support. However, these effects start to decline at the beginning of the fourth year.

positively correlated with TFP. Finally, the presence of foreign investors has no significant effect on TFP.

5.2 Identification strategies

Although we have identified a significant and positive relationship between Innofund and firm TFP, we cannot claim causality because the positive correlation may be caused by other factors. We have two major identification concerns. First, our results may be caused by selection biases. As shown in Table 2, the Innofund selection process is characterized by a "cherry picking" tendency in that the chosen firms had higher TFP than the others even before the government support was infused. Such awarded firms may effectively capture market opportunities such as export and foreign investment that outperform non-Innofund-backed ones even without government support. Second, the positive relationship between Innfound support and firm TFP may be caused by unobservable factors which co-exist with Innofund support. In such case, we can hardly establish the causal relationship between Innofund grant and firm productivity. We address the identification concerns with two approaches, namely, the PSM strategy and two-stage Hackman estimations.

First, we address the selection issues with PSM approach. We employ the PSM algorithm to construct a control sample. The propensity score is the probability of the treatment assignment, which is conditional on the observed baseline characteristics that enable us to design a nonrandomized study and to mitigate the selection issues of a randomized trial (Austin, 2011). In our context, we specifically choose PSM approach proposed by Rosenbaum and Rubin (1985) because this matching method eliminates a greater proportion of the systematic difference in baseline characteristics between treated and untreated subjects than the stratification on propensity score or the covariate adjustment using such a score does (Austin et al. 2007).

We match Innofund-backed firms with non-Innofund-backed ones with multiple dimensions for the year prior to Innofund awarding. In the context of our study, the propensity score is the predicted probability that a firm will win Innofund support. Following Austin et al. (2007), we choose matching variables which are not only related to the treatment but also to the outcome of the propensity score matching models in order to improve the balance of the matching process.

In terms of selecting the variables related to treatment, we mainly refer to the publicly announced Innofund selection criteria. As introduced in Section2, innovation capabilities are the major consideration in Innofund project selection. We therefore include the value of sales from new products, the volume of exports, and the stock of patents of firms, which are major indicators of the innovation capabilities of firms, in the matching process.[11] Some outcome-related variables are also incorporated into the PSM model. For instance, we control firm location to capture disparities in regional growth rates and levels of development that may be related to firm TFP, following the approach employed by Démurger et al. (2002). We also control the size and leverage ratio of firms that may affect TFP as well.

The matching criteria ensure that Innofund-backed and non-Innofund-backed firms are similar in many aspects which may affect the probability of obtaining Innofund support and TFP in the future.[12] Specifically, we apply the one-to-five, nearest-neighbor PSM to identify non-Innofund-backed firms. We also impose common support restrictions during matching. T-statistics of the balance tests indicate that the two groups of firms are similar in relevant aspects after PSM (the results of the balance tests on major innovation measurements are presented in Table B-3 of online appendix). Moreover, after applying PSM, we compare the means and medians of productivity and firm size between Innofund-backed firms and the firms in the control group in the year prior to Innofund awarding. With the exception of the rank-sum test conducted on TFP as estimated by the OLS approach, both the t-tests on means and the two-tailed Wilcoxon rank-sum tests on medians indicate the lack of a statistically significant difference between the two groups in terms of different TFP measures and firm size (the results of the comparisons are presented in Table B-4 of online appendix).

[11] R&D stock, human capital, and intangible asset ratio are important measures for innovation capacity. Nonetheless, ASIFP does not provide information on R&D stock or human capital. Meanwhile, the data quality for intangible assets is poor. However, the database provides data on annual R&D expenditure from 2005 to 2007. As a robustness check, we repeat the estimations based on the subsample in which R&D expenditure is controlled during the matching process for 2005 to 2007. The results of estimations based on the subsample are consistent with our main results (the results are presented in Table B-5 of the online appendix). Meanwhile, data on intangible assets are lacking for more than 80% firms in ASIFP. Hence, we lose a large number of observations if we include this variable in the matching model. We do, however, include the ratio of intangible assets over total assets with one year lag as a control variable in the estimations for a subsampled group of firms which have information for intangible assets provided. The results for the effects of Innofund stay as robust.

[12] Our results are robust after we remove the common support restrictions.

We then examine the dynamic effects of Innofund on the basis of this newly matched sample. Table 3 suggests that ***Sht_Innofund*** is significantly and positively associated with ***TFP*** when measured with the two approaches according to PSM-based analysis. After controlling rigorously for the selection biases, the result indicates that the ex-post effects of Innofund are sustained within three years. By contrast, the significance of the positive relationship between ***Lg_Innofund*** and ***TFP*** as measured by OLS and OP without time trend disappears after controlling for the selection biases by PSM, thereby suggesting that the long-run effects of Innofund are not robust. The results confirm that the ex-post effects of Innofund change over time after the fund infusion. Innofund-backed firms maintain significantly increased TFP values in comparison with non-Innofund-backed firms in the short term. However, this significance disappears with the expiration of this program after potential ex-ante selection effects are controlled using the PSM approach.

A significant limitation of the PSM methodology is its inability to capture the effects of unobservable variables. Instead of Innofund, some unobservable variables may contribute to the magnified productivity of firms. For instance, we cannot measure the R&D capability of firms or observe the management capability of executives based on existing data although both factors may contribute to firm productivity. In the present study, our main concern is to identify firms that won Innofund grants. To address the identification concerns of unobservable variables, we conduct two-stage estimation with two IVs to identify such firms.

The first IV we apply is the total number of the firms in the high-tech zones of the city in which the Innofund-backed firm is located in each given year (***Lnfirmno***). Such information is obtained from China Statistical Yearbook on Science and Technology (1998-2007). High-tech zone is a special type of special economic zones in China in which central and local governments seek to stimulate corporate R&D activities. The total number of high-tech firms in local high-tech zones signifies the overall development of corporate R&D capability and the supply of strong high-tech firms. This measure is an effective IV because the probability that local firms will be selected by Innofund increases when the province is recognized as a technology-intensive region. However, the counter-argument to this perspective is that the probability of a firm being selected by Innofund decreases in a city with many high-tech firms given the large pool of candidates that intensifies competition. Such a case may cancel out the positive relationship between the probability of a firm obtaining an Innofund grant and the number of high-tech firms in high-tech zones. Nevertheless, this counter-argument is not significantly relevant in the context of the Innofund program because the recommendation and selection procedures are operated at the provincial level. Competition does not occur at the city level. Moreover, this city-level variable should not be related to firm-specific productivity, which is the dependent variable of this study. This IV hence satisfies the two conditions of exogeneity and relevance.

The second IV is the ratio of total investment in fixed assets made by local governments over total GDP at the county level each year (***Fixassets***). The information regarding local government investments in the period of 1998 to 2007 is obtained from the city yearbooks. Under the regionally decentralized authoritarian regime in China, local governments manage economic activities and allocate resources (Xu, 2011). In addition, local governments compete with one another in terms of economic growth and gaining resources and support from the central government. Normally, the more ambitious the local government is, the more likely the government is to invest in fixed assets. Local governments that invest more in fixed assets may be highly likely to support the participation of local firms in the Innofund program competition and to exert efforts to lobby for these firms to win Innofund grants from upper-level governments. We therefore predict that firms located in a county where the local government invests more in fixed assets have a higher probability of being selected by Innofund. Nonetheless, the county-level investment made by local governments should not be related to the unobserved factors that affect the productivity of individual firms.

Our empirical model consists of a selection and an outcome equation; thus, we utilize a heterogeneous treatment model that accounts for the selection of observables and unobservables as well as for post-selection heterogeneity to conduct 2SLS (Heckman, et al., 2006). The results of 2SLS that have been derived from randomly matched samples are reported in Table 4. Panel A presents the outcomes of first-stage estimation, which indicate that the number of firms in local high-tech zones and the ratio of total investment in fixed assets made by local governments over total GDP at the county level are significantly and positively correlated to the probability that a firm wins a grant from Innofund during a given year. These findings suggest that a firm located in a city with developed corporate R&D capability and with many high-tech firms has a high probability of receiving Innofund grants. A firm is also more likely to gain Innofund support if it is located in a county that invests much in fixed assets and whose local government is ambitious. The first-stage estimations confirm the relevance of the IVs.

The outcomes of second-stage estimation are presented in Panel B. Models (1) to (3) show that the TFP of firms increases after receiving Innofund grants in comparison with that of non-Innofund-backed firms and the same firms before Innofund support is obtained. Moreover, Sargan test results (Sargan, 1958) indicate that we cannot reject the null hypothesis, thus suggesting that the two IVs are exogenous; thus, they are valid IVs. The findings stated above empirically imply that winning an Innofund grant positively affects firm productivity even after accounting for the endogenous nature of this program.

In summary, the two identification strategies used help us relax concerns with selection biases and missing variables. We confirm that Innofund exerts significant and positive effects on firm productivity in China in general. Meanwhile, the effects of Innofund are dynamic over time after the fund infusion, and the short-term effects are observed significantly stronger than the long-terms ones.

VI. Funding forms, market conditions, and the effects of Innofund

6.1 Funding forms and the effects of Innofund

As discussed in Section 3, we suggest that the subsidies in different forms provide varied incentives to firms that influence the effects of Innofund. To identify the effects of different forms of support, we construct two dummy variables to divide firms by funding forms. ***Appropriation_Aft*** equals to one if the firm has been backed by Innofund with cash appropriation and zero if otherwise. ***Loan_Aft*** equals to one if the firm has been supported by Innofund through interest-free bank loans and zero if otherwise.

Moreover, given our discovery that the effects of Innofund are dynamic over time, we wonder whether or not the effect of subsidies in different forms varies in a dynamic manner that remains unexplored in existing literature. To examine the dynamic effects of subsidies in various forms, we construct a series of variables that capture both the funding forms and the time period simultaneously. ***Loan_Bfr*** is a dummy variable that equals to one for the period within six years before a firm receives support through interest-free bank loans and zero if otherwise. ***Loan_Sht*** is a dummy variable whose value is one for the period within three years after the firm obtains interest-free bank loans support and is zero otherwise. ***Loan_Lg*** is a dummy variable whose value is one for the period between four and eight years after the firm gains Innofund through interest-free bank loans and is zero otherwise. Similarly, ***Appropriation_Bfr*** is a dummy variable whose value is one for the period within six years before a firm receives appropriation support and is zero otherwise. ***Appropriation_Sht*** is a dummy variable whose value is one for the period within three years after the firm obtained appropriation support and is zero otherwise. ***Appropriation _Lg*** is a dummy variable whose value is one for the period between four and eight years after the firm gained appropriation support and is zero otherwise.

Table 5 presents the regression results of the effects of Innofund in different forms. Models (1) to (3) report the general influences of the two different funding forms on firm productivity and indicate that ***Loan_Aft*** is significantly and positively associated with TFP. Thus, firms supported by interest-free bank loans display a productivity that is higher than that of non-Innofund-backed firms and that of the supported firms themselves prior to gaining support. We also observe a positive relationship between ***Appropriation_Aft*** and TFP as measured by OLS and OP with time trend. Nonetheless, no statistically significant relationship is observed between ***Appropriation_Aft*** and the TFP measured by OP without time trend.

Meanwhile, the Lincom test results show that the coefficients of ***Loan_Aft*** are significantly greater than those of ***Appropriation_Aft***, thus suggesting that firms supported by interest-free bank loans enjoy greater increases in productivity than those supported by appropriation do. For instance, firms supported by interest-free bank loans generate a TFP (as measured by OLS) that is approximately 0.11 higher than that of non-Innofund-backed firms and that of the supported firms prior to receiving Innofund grants. However, the gap between firms supported by appropriation and non-Innofund-backed firms as well as the firms themselves prior to Innofund infusion is barely 0.07 in terms of TFP as measured by OLS. These findings are consistent with our predictions that

Innofund support in the form of interest-free bank loans exerts stronger effects on firm productivity than the support in the form of appropriation does.

We examine the dynamic effects of Innofund in different forms as well. Interestingly, the selection effects of Innofund in the form of interest-free bank loans on the TFP measured by all three methods are significant, as shown in Models (4) to (6) of Table 5. By contrast, a statistically significant relationship is not detected between ***Appropriation_Bfr*** and TFP, with the exception of the TFP measured by OP with time trend. These results imply that with increased market discipline, the ex-ante selection effects are stronger with interest-free bank loan support than with appropriation support.

After controlling for ex-ante selection, the effects of interest-free bank loans are sustained across both short-run and long-run periods; nonetheless, the effects are stronger in the short run than in the long run. In addition, the positive effects of Innofund are observed only in the form of appropriation in the short-run period when the TFP is measured by OLS and the OP with time trend. No statistically significant relationship is detected between Innofund in the form of appropriation in the long run and the TFP measured by any method.

The results in Table 5 support our prediction that different forms of government R&D support influence the effects of Innofund. Government subsidies in the form of interest-free bank loans exert stronger effects on firms than those receiving support in the form of appropriation in China. Our results remain robust for the PSM sample (we do not present these results to save space). Such finds are consistent with our predictions that government R&D subsidies imposing both ex-ante and ex-post screening systems have stronger effects on firm TFP than those relying only on ex-ante project screening do.

6.2 Market conditions and Innofund effects

We examine the influences of market conditions on the effects of Innofund with the focus on two aspects of regional heterogeneity, namely, economic development and marketization level of the regions. First, we divide the regions into two subgroups, namely, developed and under-developed regions, on the basis of economic development as defined by the State Statistical Bureau. Second, we use the marketization index constructed by Fan et al. (2009) to segment the provinces into another two subgroups, namely, more market-oriented and less market-oriented regions. The marketization index focuses on five major aspects of market development, namely, the relationship between business and government, private sector development, the progression of product markets, resource market development, and the progression of business service agencies and legal institutions. Market-oriented regions refer to the top six provinces whose total scores are the highest. The remaining regions are defined as less market-oriented regions.

We rerun the estimations shown in Table 2 for the subsamples divided by the aforementioned measurements. Table 6 depicts the estimations of the effects of Innofund in regions with different degrees of marketization. Models (1) to (3) and (4) to (6) indicate the estimations for less and more market-oriented regions, respectively. As per Models (1) to (3), all Innofund variables are significantly and positively associated with the TFP of firms, thereby suggesting that Innofund-backed firms generate higher productivity than non-Innofund-backed firms do in less market-oriented regions both before and after the infusion of government funds. By contrast, a statistically significant relationship is merely observed between ***Sht_Innofund*** and the TFP measured by the OP approach with time trend in more market-oriented regions; thus, Innofund has no significant effects on firm productivity in such regions. Furthermore, the trends of Innofund effects in both subsamples are similar to those observed for the entire sample, namely the short-run effects of Innofund (within three years after the infusion of funds) are stronger than the selection and long-run effects.

Table 7 presents the regression results for the effects of Innofund across regions by economic development. Models (1) to (3) and (4) to (6) depict the estimation for under-developed and developed regions, respectively. All Innofund-related variables are significantly and positively associated with the TFP of firms across Models (1) to (3) (except for the ***Lg_Innofund*** measured by OP without time trend; the significance of this variable is observed at the margin). This outcome indicates the significant effects of this program in under-developed regions; Innofund-backed firms exhibit higher TFP than non-Innofund-backed ones do in both short and long runs. Meanwhile, ***Sht_Innofund*** is significantly and positively correlated to the TFP of firms across Models (4) to (6). This observation implies that firms backed by this program generate higher productivity than non-Innofund-backed firms do within three years after fund infusion in developed regions. By contrast, ***Lg_Innofund*** is significantly and positively correlated with only the TFP measured by OP with time trend, as shown in Model (5). This finding suggests that the long-run effects of Innofund on the TFP of firms in developed regions are not robust.

By comparing the coefficients of Innofund variables, we observe that the gap in the productivity levels of Innofund-backed and non-Innofund-backed firms is larger in under-developed regions than that in developed regions regardless of whether or not we focus on the selection effects or the short-run or long-run ex-post effects of Innofund. These results suggest that with all things equal, the effects of government R&D subsidies are stronger in under-developed regions than in developed regions in China. Meanwhile, the trends of the Innofund effects in both under-developed and developed regions are similar to those observed for the entire sample; that is, the effects are stronger in the short-run than in long-run period.

In summary, Tables 6 and 7 suggest that a firm located in a less market-oriented region or an under-developed province is more likely to benefit from the Innofund program than a firm situated in a province with a developed economy or market. Moreover, Innofund exerts stronger effects on the productivity increase of firms in short run than in long run. Our results remain robust for the PSM sample (we do not present these results to save space). In general, the findings are consistent with our prediction and support the "market failure" hypothesis; that is, Innofund exerts stronger effects in regions with less-functional markets.

VII. Conclusion

This study examines different factors that may influence the effects of Innofund on firm productivity. Innofund-backed firms generate significantly higher productivity after winning the subsidies comparing to non-Innofund-backed firms and the same firms prior to the infusion of Innofund. Moreover, although Innofund has significantly positive ex-post effects on firm productivity in both short and long runs, the effects are dynamic. The short-term effects are significantly stronger than the long-term ones; such results are consistent with the majority of empirical evidence (Guellec and Van Pottelsberghe, 2000; Lach, 2002; Lööf and Hesmati, 2005). Additionally, Innofund in the form of interest-free bank loans exerts stronger effects on firm productivity than Innofund in the form of appropriation does. These findings support the predictions derived from agency theory (Holmström, 1982; Hart, 1983; Dewatripont and Maskin, 1995; Aghion et al., 2013).

Finally, the effects of Innofund are heterogeneous across markets. Such influences are stronger in economically under-developed or less market-oriented provinces.

This research contributes to existing literature in three aspects. First, this study is among the few that identify the heterogeneous effects of government subsidies; this work also reveals that these effects are dynamic and vary across markets depending on the different forms of support. This study also adds to research on government R&D programs by providing a new perspective on the evaluation of government R&D policy and policy implications. Second, we successfully control for the identification challenges of cross-country studies by examining the effects of Innofund across regions, within the same country, and under the same R&D program. Third, this research is among the first systematic examinations of government corporate R&D programs in China; institutions in this country differ substantially from those in developed market economies. Hence, this study contributes to existing literature on the interactions between R&D financing and institutions.

Finally, our empirical findings have implications for government policy. The findings regarding the dynamic effects of Innofund in the short and long runs, especially the weaker influences in the long run, may indicate the limited effects of such programs on technology spillover. Meanwhile, the strengthened effect of interest-free bank loans over that of appropriation indicates a market-discipline-focused direction toward which policymakers can steer the operation of government R&D programs. Finally, the findings regarding the stronger effect in less market-oriented or less developed regions suggest that policymakers may consider allocating increased resources to support corporate R&D activities in such areas to achieve higher returns from government R&D programs.

Table 1: Summary Statistics of Innofund-backed Observations and Observations in the Control Group

Variable	Innofund-backed Obs	Mean	Std. Dev.	Min	Max	Non-Innofund-backed Obs	Mean	Std. Dev.	Min	Max	Diff	T-statistics
Firm_Age	17,845	9.98	7.42	0	29.00	63,695	10.11	7.59	0.00	29.00	0.13***	(2.06)
Firm_Size	17,847	290.21	361.35	0	3,446.00	63,713	154.51	176.49	0.00	3,446.00	−135.71***	(−48.58)
Lvg_rt	17,799	0.56	0.25	0	13.06	63,388	0.61	0.34	0.00	15.70	0.04***	(18.48)
State_Shr	17,702	0.10	0.27	0	1.00	62,776	0.12	0.31	0.00	1.00	0.02***	(8.96)
TFP_ols	16,742	0.36	0.99	−9.89	4.59	59,211	0.03	1.18	−13.42	6.58	−0.33***	(−36.79)
TFP_op1	16,745	2.70	1.44	−7.49	8.38	59,234	2.43	1.58	−11.99	9.70	−0.27***	(−21.06)
TFP_op2	16,745	2.42	1.04	−8.21	7.15	59,234	2.22	1.27	−11.01	8.80	−0.20***	(−21.06)
Variable	**Innofund-backed Obs(Loan)**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Innofund-backed Obs(Appropriation)**	**Mean**	**Std. Dev.**	**Min**	**Max**	**Diff**	**T-statistics**
Firm_Age	8,475	10.68	7.54	0.00	29.00	9,220	9.31	7.22	0	29.00	−1.37***	(−12.31)
Firm_Size	8,475	357.68	392.58	0.00	3,446.00	9,222	228.36	317.57	0	3,446.00	−129.32***	(−23.97)
Lvg_rt	8,458	0.58	0.25	0.00	13.06	9,191	0.54	0.25	0	5.32	−0.04***	(−11.53)
State_Shr	8,424	0.08	0.25	0.00	1.00	9,129	0.12	0.30	0	1.00	0.03***	(8.06)
TFP_ols	8,045	0.43	0.92	−9.89	4.59	8,557	0.30	1.04	−9.85	4.58	−0.13***	(−8.55)
TFP_op1	8,045	2.70	1.45	−7.49	8.38	8,560	2.69	1.44	−7.44	7.74	−0.01	(−0.44)
TFP_op2	8,045	2.38	0.96	−8.21	7.15	8,560	2.45	1.11	−7.65	6.96	0.07***	(4.52)

** p<=0.1, ** p<=0.05, *** p<=0.01*

Table 2: Dynamic Effects of Innofund on Firm TFP (Randomly Drawn Sample)

	(1)	(2)	(3)	(4)	(5)	(6)
	TFP_ols	TFP_op1	TFP_op2	TFP_ols	TFP_op1	TFP_op2
Panel A Dynamic Effects of Innofund on Firm TFP						
InnoAft	0.088***	0.080***	0.063***			
	(0.019)	(0.020)	(0.020)			
Bfr_Innofund				0.187***	0.213***	0.175***
				(0.068)	(0.070)	(0.068)
Sht_Innofund				0.281***	0.298***	0.244***
				(0.071)	(0.073)	(0.071)
Lg_Innofund				0.185**	0.225***	0.162**
				(0.076)	(0.079)	(0.077)
Firm_Age	0.163***	0.187***	0.081***	0.161***	0.186***	0.080***
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
State_Shr	-0.118***	-0.145***	-0.135***	-0.115***	-0.142***	-0.132***
	(0.030)	(0.030)	(0.030)	(0.029)	(0.030)	(0.030)
Lvg_rt	-0.215***	-0.200***	-0.188***	-0.215***	-0.199***	-0.188***
	(0.026)	(0.026)	(0.027)	(0.026)	(0.026)	(0.027)
Firm_Size	-0.025	-0.053***	-0.055***	-0.024	-0.053***	-0.054***
	(0.015)	(0.016)	(0.016)	(0.015)	(0.016)	(0.016)
Export_D	0.056***	0.054***	0.053***	0.056***	0.054***	0.053***
	(0.014)	(0.015)	(0.015)	(0.014)	(0.015)	(0.015)
FDI_D	0.001	0.003	-0.010	0.003	0.004	-0.009
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Constants	0.281***	2.717***	2.199***	0.245***	2.677***	2.165***
	(0.077)	(0.079)	(0.078)	(0.078)	(0.080)	(0.080)
Year Effect	Y	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y	Y
N	75472	75497	75497	75472	75497	75497
adj. R-sq	0.029	0.020	0.042	0.030	0.020	0.043
Panel B The difference between Long run effects and short run effects						
Sht_Innofund - Bfr_Innofund				0.095***	0.085***	0.069***
				(0.019)	(0.020)	(0.019)
Lg_Innofund - Sht_Innofund				-0.096***	-0.073***	-0.082***
				(0.027)	(0.028)	(0.028)

*Standard errors in parentheses * p<=0.1, ** p<=0.05, *** p<=0.01*

Table 3: Dynamic Effects of Innofund on Firm TFP (PSM Sample)

	(1)	(2)	(3)	(4)	(5)	(6)
	TFP_ols	TFP_op1	TFP_op2	TFP_ols	TFP_op1	TFP_op2
Panel A Dynamic Effects of Innofund on Firm TFP						
InnoAft	0.068***	0.071***	0.025			
	(0.019)	(0.019)	(0.019)			
Bfr_Innofund				0.125*	0.179**	0.108
				(0.068)	(0.070)	(0.068)
Sht_Innofund				0.202***	0.257***	0.143**
				(0.071)	(0.073)	(0.071)
Lg_Innofund				0.094	0.175**	0.025
				(0.076)	(0.078)	(0.076)
Firm_Age	0.191***	0.191***	0.107***	0.188***	0.189***	0.105***
	(0.021)	(0.022)	(0.021)	(0.021)	(0.022)	(0.021)
State_Shr	-0.029	-0.047	-0.052*	-0.029	-0.045	-0.053*
	(0.029)	(0.030)	(0.030)	(0.029)	(0.029)	(0.029)
Lvg_rt	-0.195***	-0.167***	-0.157***	-0.194***	-0.166***	-0.157***
	(0.030)	(0.030)	(0.031)	(0.030)	(0.030)	(0.031)
Firm_Size	-0.048***	-0.084***	-0.095***	-0.048***	-0.084***	-0.094***
	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)	(0.013)
Export_D	0.060***	0.057***	0.058***	0.060***	0.058***	0.059***
	(0.012)	(0.013)	(0.013)	(0.012)	(0.013)	(0.013)
FDI_D	-0.018	-0.018	-0.028	-0.017	-0.017	-0.026
	(0.020)	(0.021)	(0.021)	(0.020)	(0.021)	(0.021)
Constants	0.480***	2.963***	2.394***	0.457***	2.931***	2.374***
	(0.067)	(0.069)	(0.067)	(0.069)	(0.070)	(0.069)
Year Effect	Y	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y	Y
N	81098	81116	81116	81098	81116	81116
adj. R-sq	0.029	0.019	0.060	0.030	0.019	0.061
Panel B The difference between Long run effects and short run effects						
Sht_Innofund - Bfr_Innofund				0.077***	0.077***	0.035***
				(0.018)	(0.019)	(0.019)
Lg_Innofund - Sht_Innofund				-0.108***	-0.082***	-0.119***
				(0.026)	(0.028)	(0.028)

*Standard errors in parentheses * p<=0.1, ** p<=0.05, *** p<=0.01*

Table 4: Two-stage Estimations of Firm TFP

1st Stage[13]	InnoAft	InnoAft	InnoAft
lnfirmno	0.027***	0.027***	0.027***
	(0.002)	(0.002)	(0.002)
Fixassets	0.005**	0.005**	0.005**
	(0.002)	(0.002)	(0.002)
Constants	-3.01***	-3.01***	-3.01***
	(0.056)	(0.056)	(0.056)
2nd Stage	TFP_ols	TFP_op1	TFP_op2
InnoAft	1.302*	2.399***	1.457***
	(0.670)	(0.915)	(0.423)
Firm_Age	-0.074***	0.035	-0.065***
	(0.019)	(0.026)	(0.016)
State_Shr	-1.367***	-1.559***	-1.426***
	(0.107)	(0.144)	(0.080)
Lvg_rt	-0.182	-0.016	-0.234
	(0.403)	(0.543)	(0.192)
Firm_Size	-0.053*	-0.169***	-0.205***
	(0.031)	(0.041)	(0.023)
Export_D	-0.025	0.060	-0.023
	(0.030)	(0.044)	(0.028)
FDI_D	0.393***	0.310***	0.277***
	(0.043)	(0.060)	(0.044)
Constants	0.877***	3.322***	3.402***
	(0.134)	(0.177)	(0.097)
Year Effect	Y	Y	Y
Firm Effect	Y	Y	Y
N	38423	38440	38440
Sargan test P value	0.197	0.308	0.373

*Standard errors in parentheses * p<=0.1, ** p<=0.05, *** p<=0.01*

[13] All the control variables for the first stage are the same with those of the second stage. We do not present them to save the space.

Table 5: Effects of Innofund in Different Forms

	(1) TFP_ols	(2) TFP_op1	(3) TFP_op2	(4) TFP_ols	(5) TFP_op1	(6) TFP_op2
Loan_Aft	0.105***	0.100***	0.088***			
	(0.025)	(0.026)	(0.026)			
Appropriation_Aft	0.071***	0.059**	0.038			
	(0.027)	(0.028)	(0.028)			
Loan_Bfr				0.229**	0.248***	0.243***
				(0.089)	(0.087)	(0.088)
Loan_Sht				0.342***	0.351***	0.334***
				(0.093)	(0.091)	(0.092)
Loan_Lg				0.239**	0.287***	0.264***
				(0.099)	(0.097)	(0.098)
Appropriation_Bfr				0.153	0.186*	0.120
				(0.099)	(0.104)	(0.099)
Appropriation_Sht				0.229**	0.250**	0.165
				(0.103)	(0.110)	(0.104)
Appropriation_Lg				0.140	0.169	0.073
				(0.111)	(0.117)	(0.112)
Firm_Age	0.164***	0.188***	0.083***	0.163***	0.188***	0.082***
	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)	(0.021)
State_Shr	-0.119***	-0.146***	-0.136***	-0.116***	-0.143***	-0.134***
	(0.030)	(0.030)	(0.030)	(0.029)	(0.030)	(0.030)
Lvg_rt	-0.215***	-0.199***	-0.188***	-0.214***	-0.198***	-0.187***
	(0.026)	(0.026)	(0.027)	(0.026)	(0.026)	(0.027)
Firm_Size	-0.025*	-0.053***	-0.055***	-0.025	-0.053***	-0.055***
	(0.015)	(0.016)	(0.016)	(0.015)	(0.016)	(0.016)
Export_D	0.056***	0.054***	0.053***	0.056***	0.054***	0.053***
	(0.014)	(0.015)	(0.015)	(0.014)	(0.015)	(0.015)
FDI_D	0.001	0.004	-0.010	0.003	0.005	-0.009
	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)	(0.025)
Constants	0.281***	2.717***	2.198***	0.245***	2.677***	2.164***
	(0.077)	(0.079)	(0.079)	(0.079)	(0.080)	(0.080)
Year Effect	Y	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y	Y
N	75364	75389	75389	75333	75358	75358
adj. R-sq	0.029	0.020	0.043	0.030	0.020	0.043

*Standard errors in parentheses * p<=0.1, ** p<=0.05, *** p<=0.01*

Table 6: Effects of Innofund in Regions with Different Degrees of Marketization

	Less marked-oriented regions			More market-oriented regions		
	(1)	(2)	(3)	(4)	(5)	(6)
	TFP_ols	TFP_op1	TFP_op2	TFP_ols	TFP_op1	TFP_op2
Bfr_Innofund	0.250***	0.272***	0.232**	0.099	0.128	0.094
	(0.096)	(0.096)	(0.096)	(0.094)	(0.102)	(0.093)
Sht_Innofund	0.367***	0.368***	0.312***	0.154	0.185*	0.135
	(0.100)	(0.100)	(0.101)	(0.098)	(0.107)	(0.097)
Lg_Innofund	0.254**	0.264**	0.194*	0.081	0.144	0.089
	(0.109)	(0.110)	(0.111)	(0.103)	(0.112)	(0.103)
Firm_Age	0.213***	0.246***	0.136***	0.069**	0.083***	-0.016
	(0.031)	(0.031)	(0.031)	(0.027)	(0.029)	(0.028)
State_Shr	-0.148***	-0.175***	-0.175***	-0.020	-0.046	-0.020
	(0.036)	(0.037)	(0.037)	(0.051)	(0.051)	(0.052)
Lvg_rt	-0.154***	-0.144***	-0.114***	-0.296***	-0.273***	-0.286***
	(0.032)	(0.032)	(0.033)	(0.049)	(0.049)	(0.051)
Firm_Size	-0.064***	-0.091***	-0.082***	0.027	-0.002	-0.014
	(0.024)	(0.025)	(0.025)	(0.019)	(0.019)	(0.019)
Export_D	0.024	0.028	0.028	0.094***	0.088***	0.088***
	(0.026)	(0.026)	(0.026)	(0.017)	(0.017)	(0.017)
FDI_D	0.018	0.032	0.009	-0.001	-0.007	-0.014
	(0.044)	(0.045)	(0.044)	(0.030)	(0.031)	(0.031)
Constants	0.278**	2.656***	2.109***	0.236**	2.716***	2.239***
	(0.123)	(0.126)	(0.127)	(0.100)	(0.103)	(0.100)
Year Effect	Y	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y	Y
N	37318	37324	37324	38154	38173	38173
adj. R-sq	0.024	0.025	0.056	0.048	0.026	0.035

*Standard errors in parentheses * p<=0.1, ** p<=0.05, *** p<=0.01*

Table 7: Effects of Innofund in Developed and Under-developed Regions

	Under-developed regions			Developed regions		
	(1)	(2)	(3)	(4)	(5)	(6)
	TFP_ols	TFP_op1	TFP_op2	TFP_ols	TFP_op1	TFP_op2
Bfr_Innofund	0.219**	0.238**	0.198**	0.141*	0.177*	0.137
	(0.097)	(0.097)	(0.097)	(0.084)	(0.093)	(0.084)
Sht_Innofund	0.330***	0.333***	0.272***	0.202**	0.235**	0.186**
	(0.102)	(0.103)	(0.103)	(0.087)	(0.096)	(0.087)
Lg_Innofund	0.228**	0.257**	0.179	0.119	0.171*	0.119
	(0.111)	(0.113)	(0.112)	(0.093)	(0.102)	(0.094)
Firm_Age	0.210***	0.243***	0.133***	0.063**	0.076***	-0.023
	(0.031)	(0.030)	(0.030)	(0.027)	(0.029)	(0.028)
State_Shr	-0.170***	-0.193***	-0.192***	0.013	-0.024	0.006
	(0.038)	(0.038)	(0.038)	(0.046)	(0.047)	(0.047)
Lvg_rt	-0.185***	-0.171***	-0.145***	-0.263***	-0.246***	-0.258***
	(0.032)	(0.032)	(0.032)	(0.045)	(0.044)	(0.046)
Firm_Size	-0.043*	-0.070***	-0.062**	0.007	-0.023	-0.035*
	(0.024)	(0.024)	(0.024)	(0.018)	(0.018)	(0.018)
Export_D	0.051**	0.052**	0.057**	0.082***	0.079***	0.074***
	(0.025)	(0.025)	(0.025)	(0.017)	(0.017)	(0.017)
FDI_D	0.056	0.070	0.051	-0.022	-0.028	-0.037
	(0.044)	(0.044)	(0.046)	(0.029)	(0.031)	(0.030)
Constants	0.188	2.556***	2.013***	0.336***	2.840***	2.358***
	(0.121)	(0.124)	(0.124)	(0.096)	(0.099)	(0.097)
Year Effect	Y	Y	Y	Y	Y	Y
Firm Effect	Y	Y	Y	Y	Y	Y
N	39694	39700	39700	35778	35797	35797
adj. R-sq	0.024	0.024	0.052	0.049	0.025	0.036

*Standard errors in parentheses * p<=0.1, ** p<=0.05, *** p<=0.01*

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